

Fitzpatrick's exposition is relatively flawless in its execution, but it could go further in offering more intuition for some of the results derived. The three-body problem is a good example. When I teach it to upper-level physics undergraduates, I motivate the derivation of the rotating pseudopotential results regarding Lagrange points by giving a "sneak peek" expressed in terms of a force formalism. That's useful, and it's easy to do. Then I show that results using pseudopotentials are more comprehensive and more generally applicable.

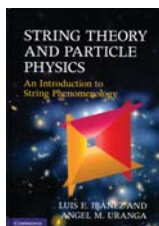
An Introduction to Celestial Mechanics is a valuable addition to the pedagogy of the field and has perhaps the clearest exposition of any celestial mechanics text for upper-level undergraduate students. For some students, Fitzpatrick will be approaching perfection. But for many others his text will need to be supplemented in parts with preparatory material. Instructors will need to be alert to how much extra motivation their classes will require.

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String Theory and Particle Physics

An Introduction to String Phenomenology

Luis E. Ibáñez and Angel M. Uranga
Cambridge U. Press, New York, 2012.
\$80.00 (673 pp.).
ISBN 978-0-521-51752-2



The field of string phenomenology has two aspects to it. One is to establish that the string theory's low-energy effective actions yield solutions that are stable, break supersymmetry, have a cosmological constant that is at least tunable to the observed value, and give rise to viable and testable predictions that do not depend strongly on the tuning. The other aspect is to demonstrate that the standard model actually exists in string theory: If it doesn't, the effective actions' solutions—whether or not they meet the criteria specified above—don't correspond to the real world. Although string-theory-derived models that resemble the standard model have appeared in the literature since the late 1980s, it is fair to say that a completely satisfactory construction, particularly when the first aspect is incorporated, has not yet been achieved.

String Theory and Particle Physics: An Introduction to String Phenomenology touches on the first aspect but focuses on the second, "model-building" side. The latter requires a thorough understanding of the full machinery of string theory, and authors Luis Ibáñez and Angel Uranga have done an excellent job of presenting that machinery in a clear and readable fashion. Both authors are distinguished researchers with a long history of important contributions to the field of string phenomenology. Ibáñez's contributions go back to the early 1980s when he and others

pioneered the field of supersymmetry and supergravity phenomenology.

The book begins with a brief introduction to the standard model and supersymmetry and leads up to the construction of the minimally supersymmetric standard model. The next few chapters discuss the basics of string theory. Of course, many more details on string theory are presented in the classic textbooks on the subject, such as volumes 1 and 2 of Joseph Polchinski's *String Theory* (Cambridge University Press, 1998; both were reviewed in PHYSICS TODAY, June 1999, page 59).

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The rest of the book is oriented toward explaining how particle-physics models are built within the string theory context. The authors provide excellent discussions of different approaches to model building. Concluding chapters deal with stabilizing the solutions from those models and extracting phenomenological consequences after supersymmetry breaking. Much of that material is not available in other string theory textbooks—at least not at such depth.

As a researcher in the field, I would have liked some discussion of string phenomenology's goals beyond trying to find a supersymmetric version of the standard model within a UV-complete framework that contains quantum gravity. Assuming that the standard model is successfully embedded in string theory, is it even possible, in principle, to get precise quantitative predictions given that string theory seems to lead to a "landscape" that implies an unfathomable number of potential solutions? If not, what is the ultimate goal of model building? Furthermore, we do not know, for example, whether the authors consider on the same logical footing all the models constructed in different weak-coupling formulations of string theory and 11-dimensional supergravity. And are those models capable of successfully addressing the cosmological constant problem and other such issues?

Nonetheless, for those who have an adequate background and who want to familiarize themselves with the basic tools necessary to begin working on string phenomenology, *String Theory and Particle Physics* is an excellent text. It is also a useful resource for experienced researchers, since much of the material, otherwise difficult to obtain (or even to read), has been curated in a pedagogically sound and clear fashion. These days, model building related to research at CERN's Large Hadron Collider is dominated by so-called BSM (beyond the standard model) work. BSM often employs string-motivated ideas, such as extra dimensions, and that makes the book timely in its demonstration of how to build models that take into account all the constraints that a fundamental theory inevitably must satisfy.

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